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QUESTIONS AS AIDS TO READING--SOME RESEARCH AND A THEORY.

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TO SUPPORT THE VIEW THAT THERE ARE SEVERAL WAYS OF CONTROLLING LEARNING BEHAVIORS, TWO APPROACHES TO STUDYING THE EFFECT OF QUESTIONS ON ADULT READING BEHAVIOR IN RELATION TO PROGRAMED MATERIALS ARE REVIEWED, AND AN ALTERNATIVE S-R MODEL IS OFFERED. THE "CYBERNETIC" VIEW PROCEEDS FROM THE ASSUMPTION THAT SENSORY FEEDBACK RATHER THAN CONFIRMATION AND REINFORCEMENT IS THE MECHANISM FOR LEARNING FROM PRINTED MATERIALS. A QUESTION MUST PRECEDE THE READING PASSAGE IN ORDER TO EFFECTIVELY CONTROL BEHAVIOR. OTHERWISE, THE LEARNER MUST BE ALLOWED TO REVIEW THE MATERIAL AFTER SEEING THE QUESTION. THE EMPHASIS, THEREFORE, IS ON CONTROL AND INTEGRATION OF RESPONSES IN TERMS OF A PRESCRIBED CRITERION, THE QUESTION. IN CONTRAST, THE "MATHEMAGENIC" APPROACH STATES THAT THE ACQUISITION AND RETENTION OF INFORMATION FROM PRINTED MATERIAL CAN BE RELATED TO ATTENTIVE RESPONSES, CALLED "MATHEMAGENIC RESPONSES," WHICH ARE CONTROLLED BY TEST-LIKE EVENTS AND THE MATERIAL IN THE PASSAGE WHICH IS ASSOCIATED WITH THAT CONTROLLING STIMULUS. A THEORETICAL S-R MODEL CONSISTENT WITH THE TWO VIEWS IS PRESENTED TO ILLUSTRATE THE PREMISE THAT LEARNING VIA REINFORCEMENT CAN BE BROADENED TO INCLUDE CONTROL OF ONGOING READING BEHAVIOR. (NS)

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Abstract

In this article the notion of control, as applied to student responses, is generalized to include the operant control of attention as opposed to the reinforcement of specific S-R associations. Research is briefly mentioned which suggests that the traditional rules of programed instruction should be qualified. A major portion of the paper outlines the effect of questions upon reading behaviors. The "cybernetic" and "mathemagenic" approaches to this problem are described and criticized, and an alternative S-R model is offered along with some related data. The view presented in this paper is that there are several ways of controlling learning behaviors and the kind of analysis that has fostered current instructional technology can be broadened to include learning from gross educational materials, such as text and prose passages.

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Questions as Aids to Reading: Some Research and a Theory

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Introduction

The success of programed instruction in teaching a variety of school subjects has served to confirm psychologist's faith in precise methods of controlling student learning — with the emphasis on control. But there is more than one way of controlling behavior and the original programing techniques may be in for some modification.

Research suggests that there are conditions under which the usual requirements of programed instruction, such as providing immediate formal knowledge of results or breaking the material into small pieces or steps of easily acquired information, may not be required (Alter & Silverman, 1962; Ausubel, 1963; Glaser & Taber, 1961; Hershberger & Terry, 1965). It has been shown that adding incidental material to programed frames may actually improve learning of the relevant S-R associations (Faust & Anderson, 1967). In short there may be several paths to the same academic goal. Current research reflects a shift of attention toward more general techniques of instructional control. These techniques include the use of questions which serve a review or preview function (Merrill & Stolurow, 1966), the use of maps, pictures, diagrams, charts, and graphs (Fleming, 1967; Reynolds, 1966; Samuels, 1967), and capitalizing upon the potentially meaningful structure of the learning material (Ausubel, 1963; Gagne, 1962). An increasing amount of analysis and research is being devoted to learning from gross instructional material such as prose or text-book passages (Frase, 1967a; Musgrave & Cohen, 1966; Rothkopf, 1965, 1966; Rothkopf & Bisbicos, 1967).

Anderson (1967) seems to have put his finger on the critical issue concerning control in relation to instructional materials when he stated that "...the most compelling stimulus in a frame is the question which must be answered or the blank which must be completed." Without doubt questions are useful tools. They are relatively easy to construct and they can be used with almost any kind of educational material. Unfortunately, we don't know a great deal about how they work. Although experimental research on questions is not a virgin area (Distad, 1927; Holmes, 1931) the current approaches to this problem are more sophisticated in terms of experimental and statistical methodology, and also in terms of the theories presented.

The present paper reviews two theoretical approaches to the effect of questions upon adult reading behaviors. Criticisms of the theories are offered and an alternative theory is proposed. The attempt here is to provide a model which is precise enough to suggest some new experiments which will confirm or modify the theory.

To summarize this theory briefly, effective reading behaviors

are conceived as a variety of attentive responses which are under reinforcement control of question-correlated stimuli. Words in a prose passage which are related to a question tend to distribute the students' attention according to the position of those words and the position of the questions. By manipulating the position of sentences or the kind of questions used the distribution of reinforcements is changed. Different schedules of reinforcement are predicted to have different effects upon the acquisition and retention of information from the sentences.

Recent Approaches

Two of the most suggestive approaches concerning the effect of questions upon the acquisition of information from printed materials are the "cybernetic" and "mathemagenic" approaches. The cybernetic view (Hershberger & Terry, 1965; Smith, 1966; Smith & Smith, 1966) states that a question is used by a student to determine if achieved behavior (the answer the student gives) meets the criterion of acceptable behavior (the correct answer). When asked "What did John X invent?" the student searches through the reading passage until he can fill in the blank. If he reads the passage and has not found the answer an error signal is generated. In other words an error is negative feedback which can be used by the student to control his reading behavior until he matches the criterion. The emphasis here is upon the matching or comparator function of questions, (Stolurow, 1961). The assumption underlying the cybernetic hypothesis is that a question must precede the reading passage in order to effectively control behavior, or, if it doesn't precede the passage then the student must be allowed to review the material after seeing the question. It is also possible to provide the student with feedback immediately after he responds to the question in the form of knowledge of results. Providing immediate knowledge of results should be an optimal procedure for facilitating recall of the specific information tested since it minimizes the time interval between performance and the criterion evaluation. Smith and Smith (1966) report a number of studies concerning motor performance in which feedback interval was a critical event in attaining adequate performance, yet Hershberger and Terry (1965) found that intervals of delay between self-instruction and testing were not critical for errors made within the program. These authors concluded that a confirmation procedure was least effective because students were led to terminate their reading too early. An erroneous feeling of confidence was engendered by the knowledge of results. Evidently, it was the kind of question (in regards to difficulty) which was the important condition for learning. The data of Anderson and Faust (1967) suggests that making a programed frame more difficult by introducing irrelevant stimuli gets the student to at least notice the relevant stimuli rather than concentrating only upon response terms. Rothkopf (1965) also found that if the correct response is easy to predict less will be learned. Frase (1967b) asked students to underline words in a passage which would comprise a complete sentence answering various types of questions. Even though the passage contained only 36 words and several practice tasks were given, students neglected to underline required stimulus words, but no student neglected to underline the response term.

Errors were always made on the stimulus portion of the sentence. For instance, when asked "When were the men in the following paragraph born?" students neglected to underline "John was born in", but they always underlined "1927". This effect was only obtained with questions that asked for a great deal of information. Obviously, students adopted what they felt to be an efficient learning strategy — practicing the response terms. For optimal learning, however, both stimulus and response terms must be associated. There is a clear need for further research to determine the precise effects of different kinds of questions upon reading behaviors.

9 The cybernetic approach to the problem of how questions facilitate performance states that sensory feedback is the mechanism for learning from written materials, rather than confirmation and reinforcement. The emphasis is upon control and integration of responses (presumably observing responses of some sort) in terms of a prescribed criterion. The student operates as a closed loop system. If he has a criterion and is allowed to review material, then formal knowledge of results is not necessary. He will not "exit" the task (Miller, Galanter, and Pribram, 1960) until he answers the question. Unfortunately, little is known about the precise kind of events which might be useful criteria in a reading task except what is known from research conducted outside the theory itself. The theory offers no exact data concerning the relationship of criteria, whether these be stimuli (in the form of questions) or responses (in the form of answers), to the reading material and ultimately to retention. The results of Hershberger and Terry (1965) and others mentioned above showing that easy questions can be detrimental, suggest that this is an important area of investigation.

The cybernetic approach does not attempt to specify each event occurring during the process of relating behavior to criterion performance, but development of the theory is contingent upon a calculus of relationships between criterion stimuli and appropriate control of responses (Attneave, 1966). An understanding of cybernetic control will be incomplete until the theory is elaborated in terms of critical S-S, S-R, and R-R relationships, and in terms of methods of establishing control over desirable relationships.

Rothkopf's "mathemagenic" approach, in contrast to the cybernetic approach, stresses that the acquisition and retention of information from printed material can be related to a variety of attentive responses, summarized by the term "mathemagenic" — they give rise to learning. These responses are under the control of test-like events (such as questions) which occur in conjunction with the reading materials. According to Rothkopf's view the critical events for learning from printed materials are the attentive responses which occur during reading, rather than the particular questions (or criteria) used. Although questions and mathemagenic responses are related, the theory places special emphasis upon the contiguity of attentive responses and the question-relevant material. With predictable use of questions the mathemagenic responses become more precise.

The function of test-like events, according to Rothkopf (1966), is to modify the nominal stimulus material into effective stimulus

components. His subdivision of nominal stimulus material into effective stimulus material on the basis of questions or instructions which precede reading, although quite suggestive, glosses over the precise nature of the interaction between the mathemagenic responses and stimulus material. On the other hand, the theory states quite clearly that the most critical event is the attentive or mathemagenic response, in relation to the controlling stimulus (question) and the material in the reading passage which is associated with that stimulus. The present paper describes in some detail the process by which this control might be achieved.

Several studies (Rothkopf, 1966; Rothkopf and Bisbicos, 1967; Frase, 1967a) have found that retention of prose material which is incidental to the questions asked is highest when the questions are placed after the reading passages. The results of these studies indicate that both pre-questioning and review questions have a facilitative effect upon the retention of the question relevant information, but that review questions can be generally facilitating. Groups given questions before passages tended to retain even less incidental information than a control group which did not read the questions. The depressing effect of specific pre-questioning confirms the cybernetic approach which suggests that when a question occurs before the reading passage students are provided with a criterion which focuses their attentive responses. Such a focusing effect would also be predicted by the mathemagenic theory, but in addition, the occurrance of general mathemagenic responses also accounts for the facilitative effect of questions when they occur after passages. There seems to be no direct way of predicting facilitation by post-questioning in terms of the cybernetic approach since students in the Frase (1967a) study were not allowed to review. Rothkopf (1966) also found that a group which had received only general instructions to read carefully performed better than the control group. Under these conditions there would be little opportunity to apply any specific internalized criterion. Frase (1967a) concluded that the results of these studies were best accounted for by the mathemagenic theory. He also pointed out that the words "preview" and "review" may be misleading because a review question could effectively shape attention on passages following the question, rather than on the passage to which the question relates. The mathemagenic approach stresses the shaping of effective reading behaviors but it does not spell out the process in detail.

An attempt to summarize the data previously cited is given below in terms of a theoretical model which emphasizes the reinforcement of attentive responses, as opposed to the reinforcement of specific verbal responses via knowledge of results. The model proposed is consistent with the cybernetic and mathemagenic approaches in the sense that it emphasizes control of the behaviors which facilitate learning rather than the responses to be learned. The basic problem at issue here is the stimulus control of appropriate study habits.

Theoretical Interpretation

In the analysis below the process by which a student learns to respond differentially to specific and general questions is described. In summary, students initially read passages and then receive test questions over the passages. Specific (factual) or general (comparative) questions become discriminative stimuli for a response which modifies further reading in terms of the number of associates (of the question) in the reading passage which can reinforce the attentive response.

Acquisition of Test-Taking Responses

Development of control by specific factual questions.

$$R_a \text{ — } \begin{matrix} S_1 \\ S_2 \end{matrix} \ (S_1^D) \text{ — } R_1 \text{ — } S^r$$

Diagram 1. Reinforcement of attention to specific facts during reading.

$$S_{q1}^D \text{ — } R_a \text{ — } S_1^r$$

Diagram 2. Selection of reinforcing stimulus by a factual question.

Diagram 1 states that during acquisition of relevant test-taking skills the student makes a general attentive response (R_a) — he looks at the reading passage, but his attentive response is not differentially affected by the stimuli within the passage. The passage might be, for example, "John was born in 1927. Bill was born in 1928." In Diagram 1 the first sentence is labeled S_1, the second sentence S_2. The bars connecting symbols refer only to temporal order. The latter part of Diagram 1 represents a typical exam question. "John was born in" is labeled "S_1^D" since it is a discriminative stimulus for the response R_1 ("1927"). Getting the correct answer R_1 to the question is followed by reinforcement (S^r), such as praise or a passing grade. Specific statements, such as S_1 and S_2, acquire the capacity to reinforce R_a because they occur early in the chain. A question becomes a discriminative stimulus because the student is reinforced with a correct answer for paying attention when the question occurs. In Diagram 2 the question S_{q1}^D is a discriminative stimulus for an attentive response which can be reinforced by S_1. For instance, the question might be "When was John born?". The student would read the passage paying special attention to "1927". Another way of saying this is that R_a is reinforced by S_1. In essence, changing the events which can reinforce R_a by introducing questions or specific instructions is a means of determining what the effective stimulus will be.

The basic mechanisms assumed to operate here are negative reinforcement (S_1 reduces uncertainty — see Berlyne, 1960), and stimulus generalization (the question and stimulus within the passage are related because they have a common associate "John's birth"). The range of this generalization, in terms of the material within the passage, is determined by the kind of question that is asked, as will be seen below. If factual questions were repeated several times R_a would tend to be reinforced by all facts when a new reading passage was encountered. This situation is

described later in terms of an anticipatory goal mechanism when consideration is given to how an irrelevant question can facilitate retention.

Development of control by comparative question.

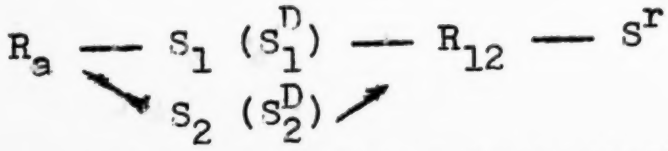

Diagram 3. Reinforcement of attention to several facts during reading.

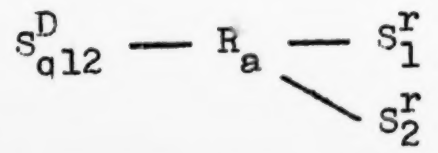

Diagram 4. Selection of reinforcing stimuli by a comparative question.

Using the same two-sentences as above, a comparative question (S^D_{q12}) such as "Who is older, John or Bill?" becomes a discriminative stimulus for an attentive response which can be reinforced by both relevant portions (S_1 and S_2) of the passage. The process described in Diagram 4 is preceded by relevant training on comparative questions, illustrated in Diagram 3. The same analysis used for Diagrams 1 and 2 applies to these examples.

The present theory distinguishes between a specific and more general question in terms of the number of question-correlated stimuli within the passage. The implication is that it should be possible to define the facilitative effects of questions in terms of the number and distribution of associates within the passage. In a preliminary study (Frase 1967b) the present author has asked students to underline words in passages which comprise an answer to the question which preceded the passage. By dividing the number of words underlined by the total number of words in the passage an index of diversity was arrived at for different questions which strongly confirmed the experimenter's categories of "specific", "comparative", and "general". Aside from trying to scale questions, a major aim of the study is to determine if these questions are differentially related to the amount of information retained from the passage.

The present model attempts to state explicitly which events can reinforce attentive responses and to provide a framework within which to view the problem of how questions control the attention of students. The point of view being presented assumes that learning via reinforcement, in the sense of specific knowledge of results formally presented, can be broadened to include the control of ongoing reading behaviors. The previous section suggested how this control is established initially. The section below describes the utilization of test-taking behaviors along with some implications and related data.

Questions preceding passages. When the student encounters a relevant question before he reads a passage of material we have the situations described in Diagrams 2 and 4 for specific and comparative questions, respectively. Usually a reading passage has more than two sentences some of which might be irrelevant to any meaningful question that could be asked. In Diagrams 5 and 6 an additional element is added. The basic difference between

$$S^D_{q1} \text{ — } R_a \text{ — } \begin{matrix} S^r_1 \\ S^r_2 \\ S^r_3 \end{matrix}$$

Diagram 5. Selection of reinforcing stimulus from a large set by a specific question.

$$S^D_{q12} \text{ — } R_a \text{ — } \begin{matrix} S^r_1 \\ S^r_2 \\ S^r_3 \end{matrix}$$

Diagram 6. Selection of reinforcing stimuli from a large set by a comparative question.

the specific and comparative question is in terms of the number of reinforcing events available for R_a. The implication is that there will be a higher rate of reinforcement with comparative questions and hence better retention of the material in general than with specific questions. This is another way of saying that with an increase in signals there will be an increase in the number of signals detected (Deese & Ormond, 1953) and that the fewer the signals the lower the vigilance (Holland, 1958). If R_a is emitted at a high rate (since it receives more reinforcement with comparative questions) it is also possible that facilitative effects will diminish rapidly. Manipulating the generality of questions in this way changes the schedule of reinforcement for R_a. There should be an interaction between question type and length of reading material in terms of retention scores. General questions should be least effective with long reading passages.

Additional questions arise if we consider the spacing of reinforcement. In Diagram 6 the comparative question might relate to S_1 and S_3. Assuming that students read sequentially, the irrelevant stimulus sentence would occur between two reinforced attentive responses. Can questions be constructed which will reinforce R_a at points which are critical for general retention? Does the distribution of reinforcements make a difference in retention? In effect this is the problem of how to optimize the structure of reading material.

Still another suggestion concerns the use of multiple schedules

of reinforcement. Paragraph headings may be used to signal the use of new schedules of reinforcement. For instance, if a student is told to find out all he can about "Bill" and he sees a paragraph heading "John", in effect the heading tells him that he will not be reinforced if he reads that paragraph. The student can anticipate and select his own schedules of reinforcement.

Another implication of the present model is that the time or number of intervening events between S_q and S^r will differentially affect retention of relevant and incidental stimulus material. In Diagram 6, S^r_3 would be incidental. The diagrams indicate that the reinforcement effect of incidental stimuli upon R_a is constant and at a lower level than the effect of relevant stimuli. Retention of incidental material should remain unaffected as the interval between S_q and reading increases, whereas retention of relevant material should drop. Frase (1967a) found confirmation for this view in that the size of reading passages between questions did not affect retention of incidental material but it did affect retention of the relevant material.

Another condition which should be considered is the use of knowledge of results upon R_a, depicted in Diagram 7. Since the

$$(S^D_{q1} \text{ — } S_1 \text{ — } R_1) \text{ — } R_a \text{ --- } \begin{matrix} S^r_1 \\ S^r_2 \\ S^r_3 \end{matrix}$$

Diagram 7. Effect of knowledge of results upon selection of the effective stimulus.

reinforcing mechanism for R_a is presumed to be the reduction of uncertainty there should be reduced reinforcement value of S^r_1 within the passage when knowledge of results is given with questions. In Diagram 7, the question S^D_{q1} is followed by the prompted response R_1. Hence, uncertainty reduction occurs before the passage is read. Although retention of R_1 will be relatively high under these conditions, due to the short interval between response and reinforcement, the attentive response should receive less reinforcement during reading. As a consequence students may lose interest in the reading passages rather rapidly, and this loss of facilitation should be more serious for general questions than for specific questions because of the larger number of associates within the passage. This could be a reason why Hershberger and Terry (1965) felt that confirmation led to an erroneous feeling of self-condidence, R_a, or paying attention while reading, received less reinforcement.

Questions following passages. Usually questions are found after reading passages, for instance, at the end of textbook chapters. If students are allowed to review the passages then the effect of these questions could be the same as if the questions had preceded the passage. According to the cybernetic theory most precise control of behavior can be achieved if questions precede reading. Research, and the theory outlined above, suggest that for general retention pre-questioning may not be the most

desirable strategy when specific questions are used. In the analysis below it is assumed that students are not allowed to review reading passages, hence a "review" question can only function to repeat information which occurred in the passage. But a question which follows a paragraph may influence attentive behaviors on the passage which follows it. It can act as an irrelevant question preceding the next passage, and it may contain a hint of what will be asked if a question follows the next passage. This "hint" is viewed as an anticapatory goal mechanism, r_g---s_g (Hull, 1952), which is related to a divergent hierarchy of responses. Since an irrelevant question precedes the paragraph the student must rely upon the conceptual categories of factual questions (r_f---s_f) or comparative questions (r_c---s_c). The hierarchy of conceptual responses can be manipulated by the kinds of questions used. In

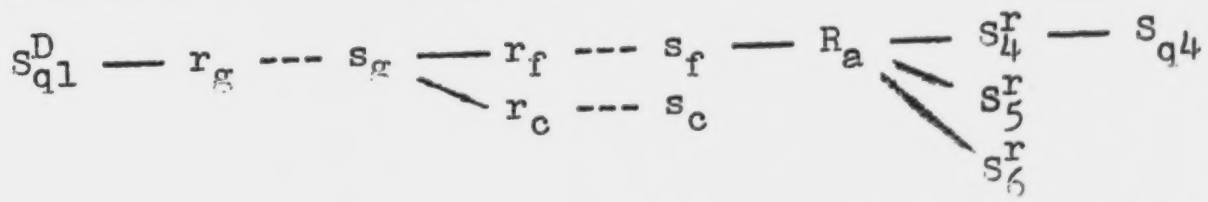

Diagram 8. Effect of specific post-question upon subsequent effective stimuli.

Diagram 8.the specific question is a discriminative stimulus for a conceptual response (factual), which means that any fact will be able to reinforce R_a. When the relevant question does occur at the end of the passage (S_{q4}) it serves to confirm the use of the conceptual category. The general implication is that placing an irrelevant question before paragraphs should have general facilitative effects. Another way of doing this would be to place relevant questions after paragraphs, giving them both a review function and a general facilitative effect upon R_a. In the studies by Rothkopf (1966) and Frase (1967a) it was found that questions had the most facilitative effect upon retention of incidental information when the questions followed reading passages. Hence the interpretation given in Diagram 8 is confirmed. Much the same

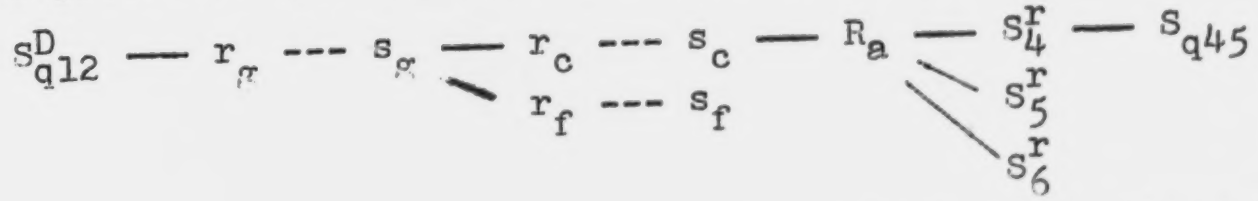

Diagram 9. Effect of a comparative post-question upon subsequent effective stimuli.

condition holds for comparative questions when used after passages (Diagram 9). When an irrelevant question precedes a series of paragraphs, R_a is reinforced by just as many stimuli whether a specific or general question is used. The assumption is that a comparative question requires knowledge of the specific facts. This seems to be a reasonable hypothesis in light of a study by Siegel and Siegel (1965). They found that students who studied passages with a conceptual set were also able to recall specific facts.

Equivalence of specific and comparative questions is not the case when questions precede the reading passage, as in Diagrams 5 and 6, hence there should be an interaction between the type of question and the position of questions. The anticipatory goal mechanism proposed to account for these differences would also account for the fact that Rothkopf (1965) found that instructions to pay attention to facts (without questions) resulted in improved retention.

In terms of the theory presented the optimal procedure for general retention is to place questions after paragraphs, and to have the questions occur frequently. In determining the effects of such manipulation it is necessary to distinguish between retention of question relevant information and retention of incidental information. Obviously, the most specific control of R_a is achieved when questions precede the reading passage. If the objective is to control the general reading behaviors of students, and not simply to improve retention of specific information, it is necessary to make reinforcement contingent upon reading all of the passage. This is most effectively done by shaping reading behaviors with post-questions. The most facilitating pre-questions would be the questions which have the largest number of associates within the passage. These questions would probably fall into the category of application or synthesis items (Bloom, 1956).

The Nature of the Attentive Response

It is obvious that R_a is a summary term for a variety of behaviors which may include focusing of the eyes, increased scanning, postural adjustments, etc. These behaviors correspond to the mathemagenic responses postulated by Rothkopf (1965). The occurrence of stimuli which are associated with questions should bear some relation to changes in EEG rhythms, pupillary dilation, etc., which might fruitfully be used to observe changes in behavior related to question associates.

Another approach, being pursued by this author, is to select some response which reflects attention. Studies are now being pursued in which prose sentences of equivalent length are presented at a fast rate via projector. The student can stop the projector on a sentence by pressing a bar, and he can stay with a given sentence only by holding the bar down. The time on each sentence is stored on a cumulative recorder. The major question to be answered by this research is whether fixed and variable schedules built into the sentence sequences lead to predictable response curves. Scant data is available at present, but the methodology looks promising. Figures 1 and 2 present cumulative time curves from two representative subjects who went through 52 sentences twice on one occasion. The sentences contained a description of four boys each having 13 characteristics. The subjects were given a pre-question asking them, "What can you tell me about Bill." The first 15 sentences (baseline) and last 11 (extinction) were not about Bill. During Trial 1 every other sentence from 15-42 was about Bill — half the sentences were question-correlated stimuli. The theory presented in this paper assumes that question-correlated

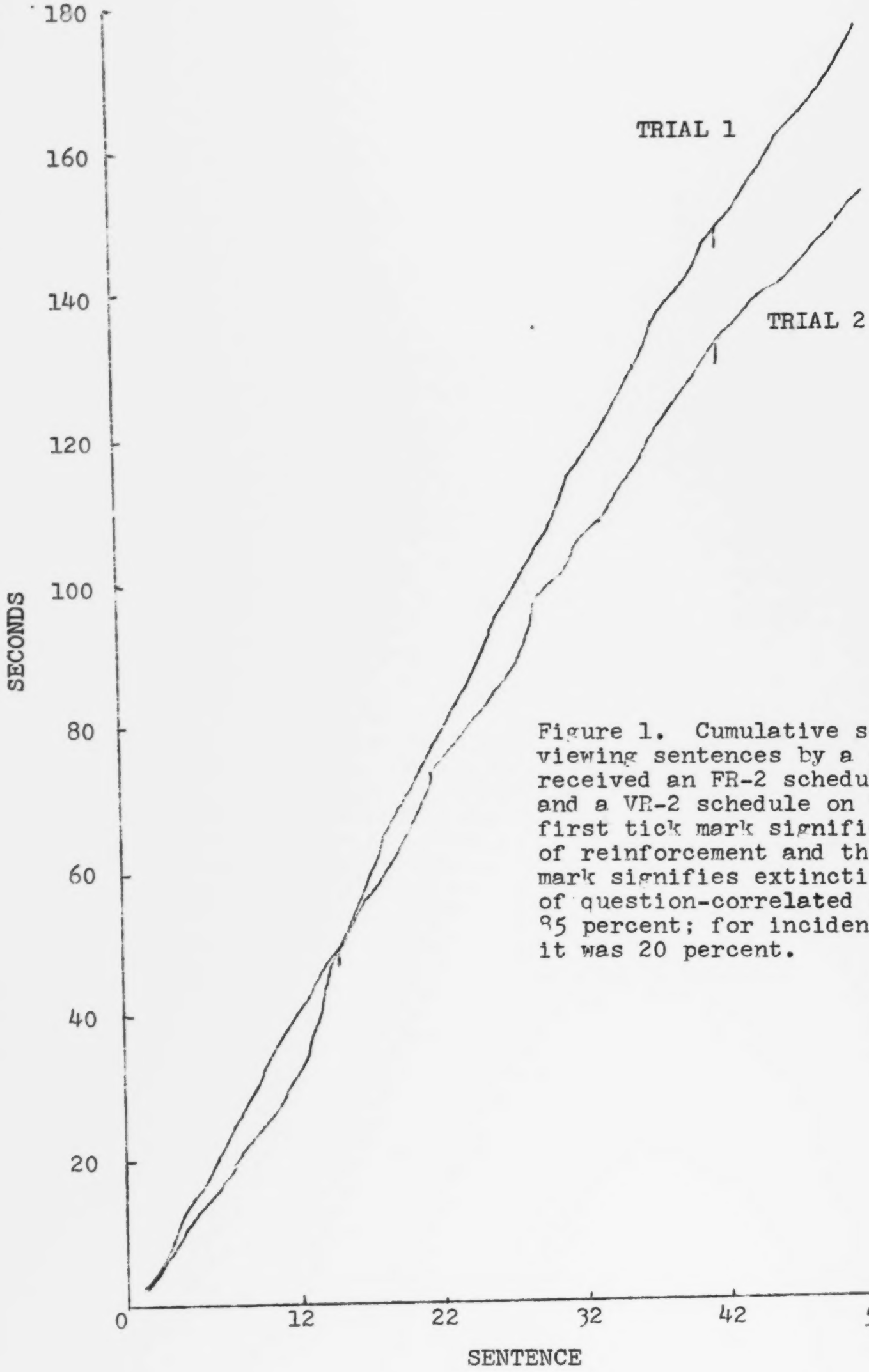

Figure 1. Cumulative seconds spent viewing sentences by a subject who received an FR-2 schedule on Trial 1 and a VR-2 schedule on Trial 2. The first tick mark signifies the onset of reinforcement and the second tick mark signifies extinction. Retention of question-correlated sentences was 85 percent; for incidental sentences it was 20 percent.

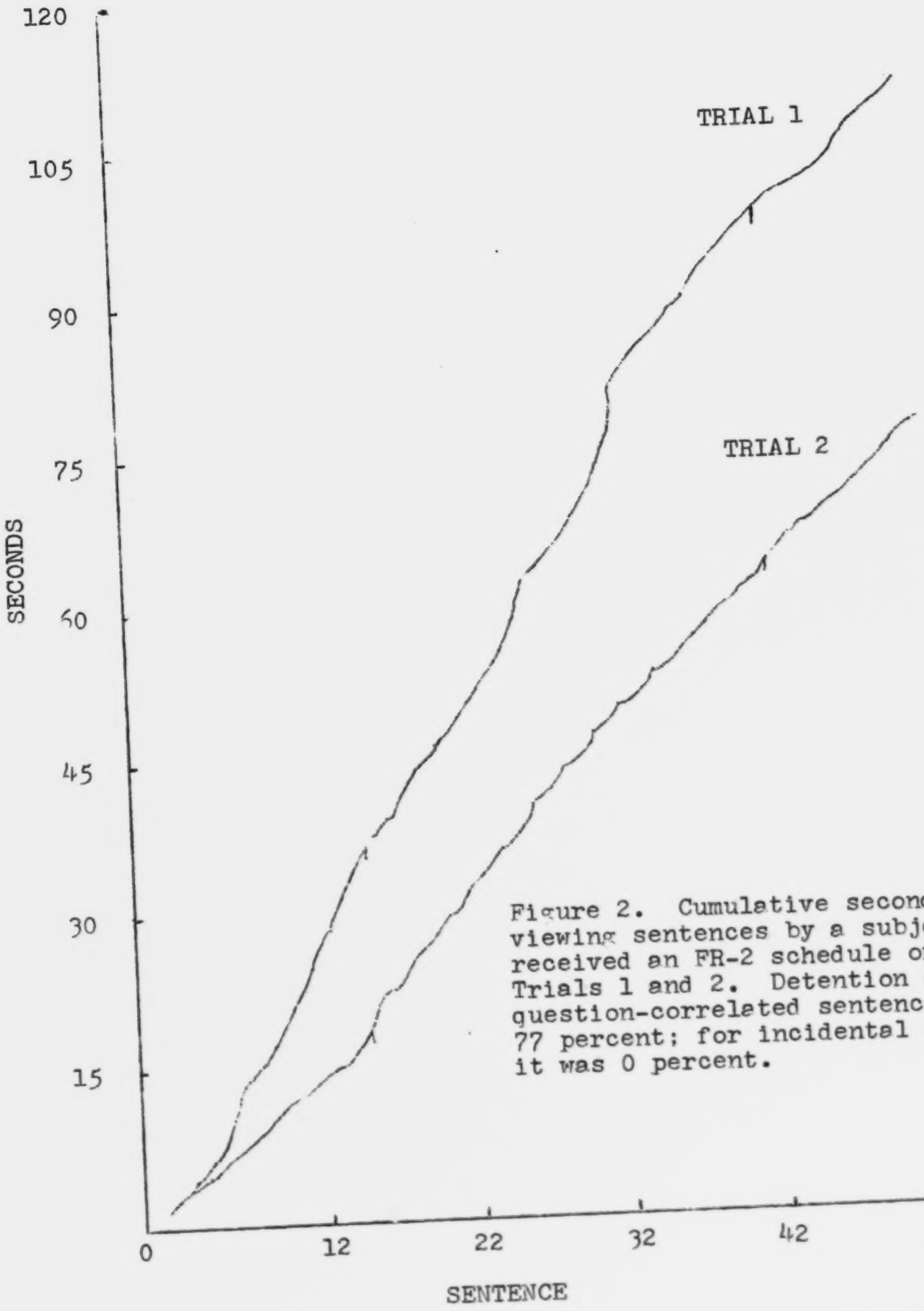

Figure 2. Cumulative seconds spent viewing sentences by a subject who received an FR-2 schedule on both Trials 1 and 2. Detention of question-correlated sentences was 77 percent; for incidental sentences it was 0 percent.

stimuli reinforce observing responses, hence Trial 1 in both figures represents an FR-2 schedule. On Trial 2 sentences 15 - 42 were randomized for the subject in Figure 1 making it a variable ratio schedule (VR-2). The same FR-2 schedule was presented to the subject in Figure 2 on the second trial.

The curves for both subjects on Trial 1 are similar in that they show irregularities and are steeper than on Trial 2. In short, the first time through the sentences reading behaviors did not conform to the theoretical model proposed in this paper. Trial 2 behavior is quite another matter. For both subjects the curves turn upward abruptly shortly before the onset of the relevant sentences (about sentence 12). Evidently the subjects anticipated the occurrence of question-relevant sentences and slowed down accordingly.

Figure 2 shows a scalloped effect characteristic of fixed ratio schedules. Figure 1, on the other hand, is what one would expect with a variable ratio schedule. The subject under the VR-2 schedule only reduced his total time by 14 percent (25 seconds) on Trial 2, while the FR-2 schedule led to a reduction in time of 35 percent (35 seconds). The variable ratio schedule may lead to higher maintainence of attention. In all respects the behavior of the student under the variable schedule was superior. He retained more of the relevant and incidental information, and his attention tended to persist. The high initial rate of response of the one subject no doubt accounts for much of the difference in retention, but there is one important correspondence between the curves of the two subjects which makes the data especially interesting. Reading responses on Trial 2 follow the theory proposed in this paper quite nicely — Trial 1 responses do not. Evidently when subjects are familiar with the material — when they know where the relevant stimuli are — their behavior becomes more precise and hence it is more directly under the control of the question-correlated stimuli. In this respect the data clearly reveal the development of effective mathemagenic responses. The methodology chosen for this exploratory work reveals rather striking changes in the topography of responses with subject-matter experience.

Summary

The theoretical model offered in this paper is "static" in the sense that it deals with several discrete events. It is assumed that the sentence is the basic meaningful unit of adult reading behavior, and that sentences can be categorized in terms of their reinforcement value for a particular attentive response. The reinforcing sentences — or effective stimuli — are determined by other specified stimulus conditions, namely, questions. When these discrete events are put together into the theory proposed in this paper, the end result is a reasonable alternative to the terminology of the cybernetic or mathemagenic approaches.

The view presented in this paper retains the advantage of dealing with response-produced feedback mechanisms and ongoing

changes in reading behaviors, while abstracting some of the most critical events in the process. The terminology employed may suggest some useful research analogies to previous operant research. The methodology has produced some interesting initial data and it may suggest some new lines of exploration.

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